

# Municipal Stormwater System Inventory & Data Collection

City of Greensboro, NC



## INVENTORY 101

Presented by:



**Erosion & Sediment Control Design Seminar**  
**Sponsored by NC DENR Land Quality**

New Bern, NC

February 8, 2000

# Presentation Outline

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- Goals of the Inventory
- Project History
- Project Description
- Innovative Field Procedures
- Problems / Pitfalls
- Future Uses of the Data

# Inventory Goals

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- Establish location, condition, size and system connectivity of infrastructure and conveyance system.
- Comply with NPDES Stormwater Permit.
- Use data for proactive planning, maintenance, work order requests.
- Identification of illicit discharges & tracking spills
- Further identification of flooding / water quality problem areas
- Link the GIS inventory data with modeling software for Watershed Master Plans.

# Presentation Outline

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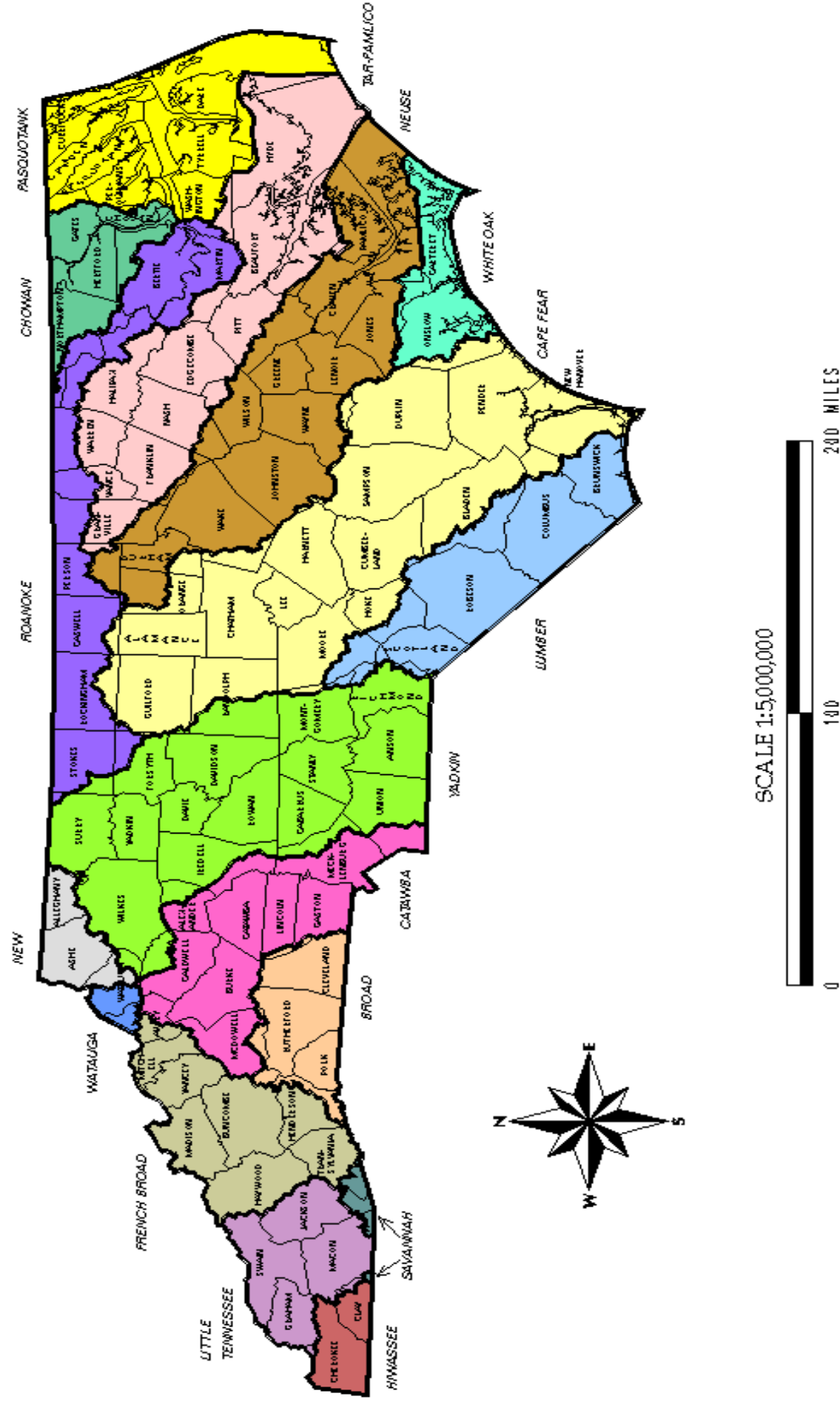
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# Project History

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- Phase I: Pilot Basin Inventory
- Phase II: North & South Buffalo Creek  
Sub-Watersheds 1 & 2
- Phase III: Citywide Inventory

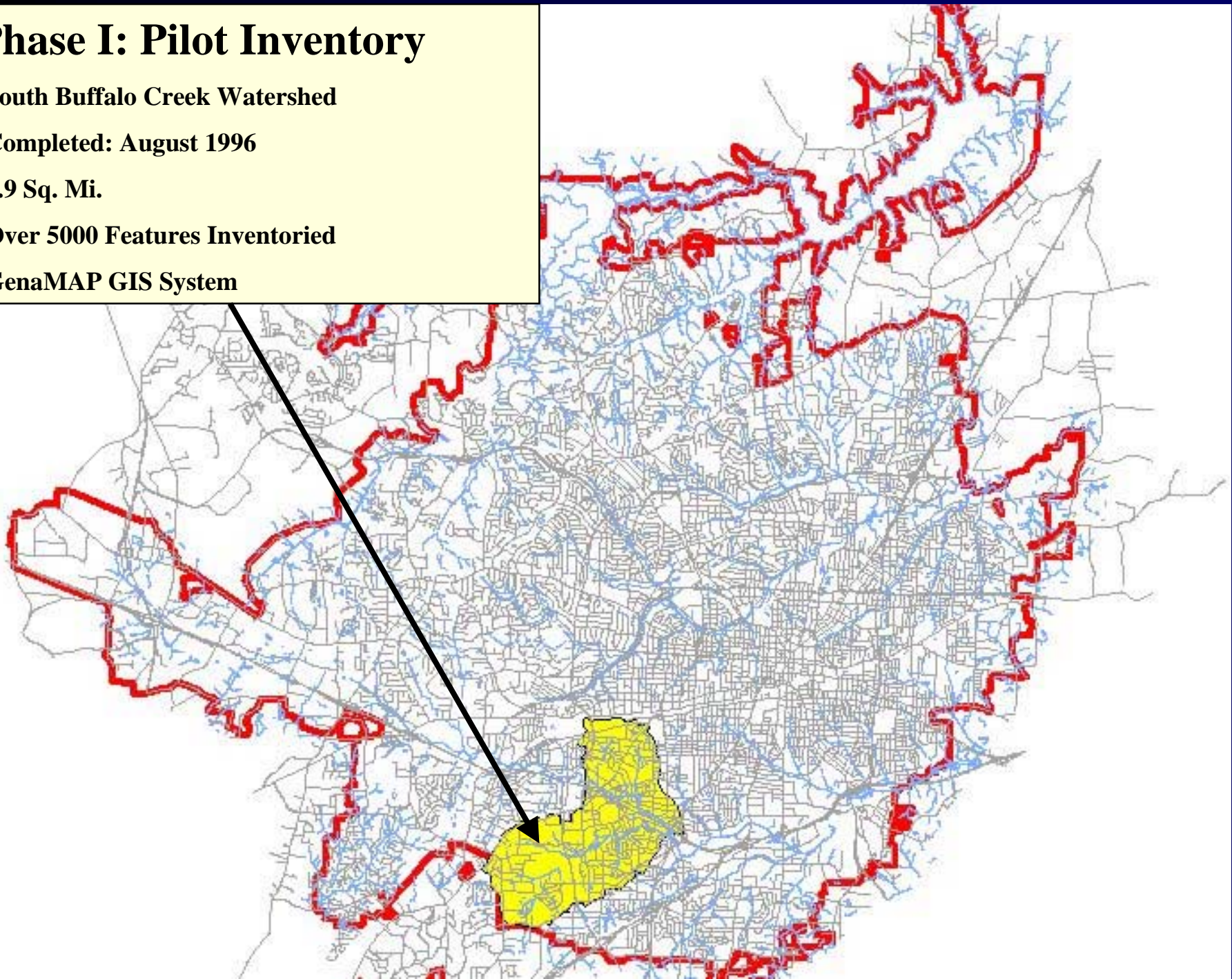
# NORTH CAROLINA RIVER BASINS





## Phase I: Pilot Inventory

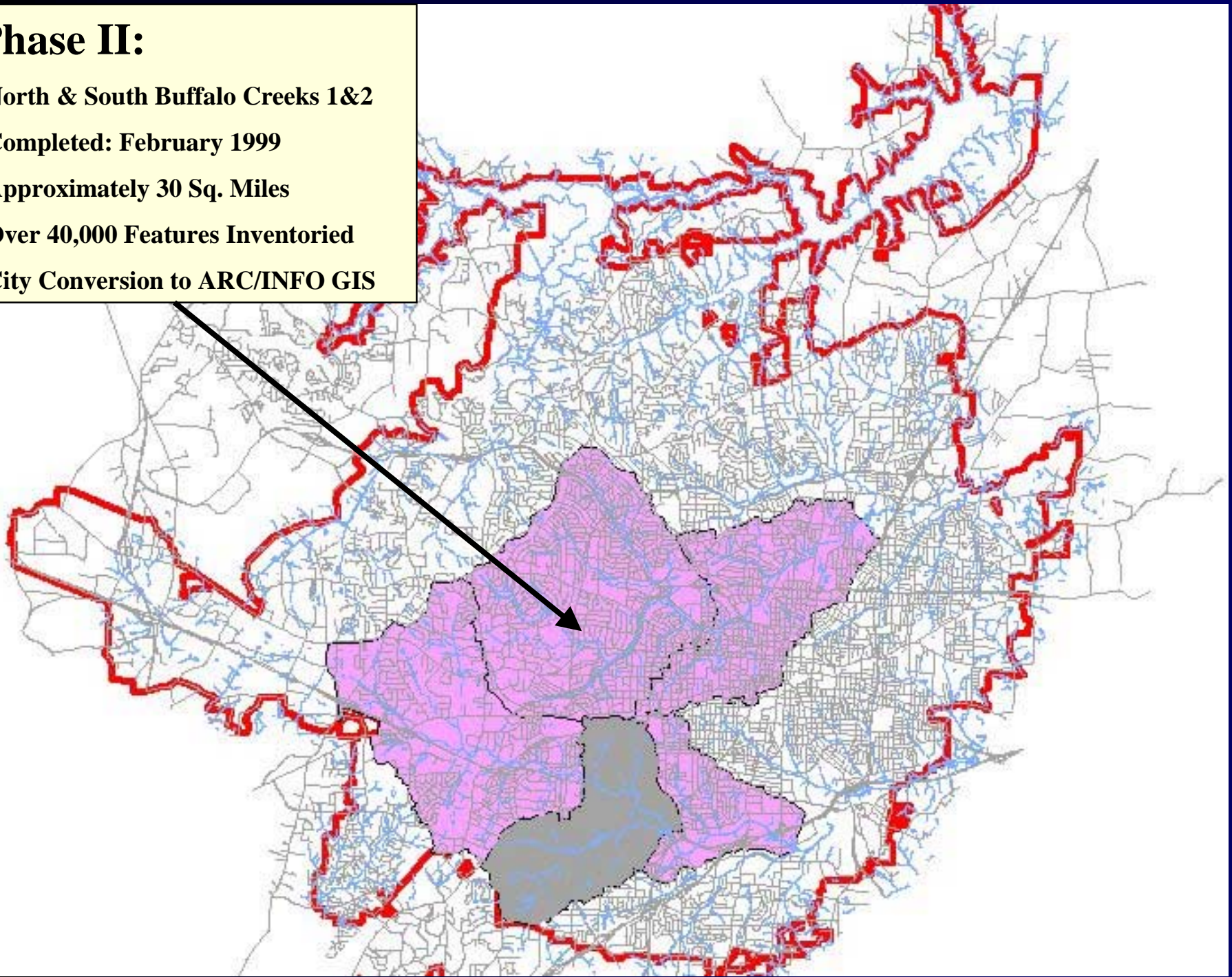
- South Buffalo Creek Watershed
- Completed: August 1996
- 3.9 Sq. Mi.
- Over 5000 Features Inventoried
- GenaMAP GIS System





## Phase II:

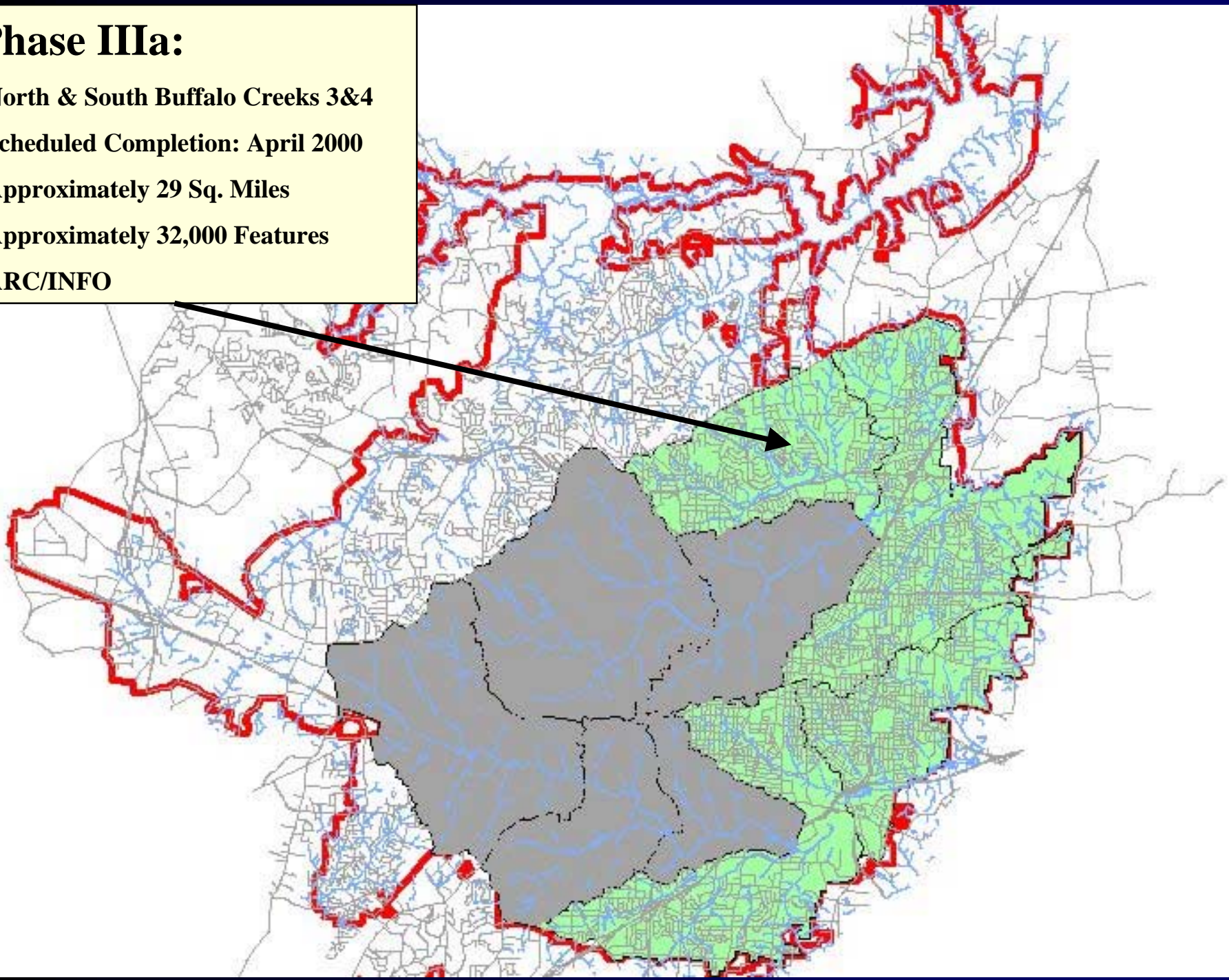
- North & South Buffalo Creeks 1&2
- Completed: February 1999
- Approximately 30 Sq. Miles
- Over 40,000 Features Inventoried
- City Conversion to ARC/INFO GIS





## Phase IIIa:

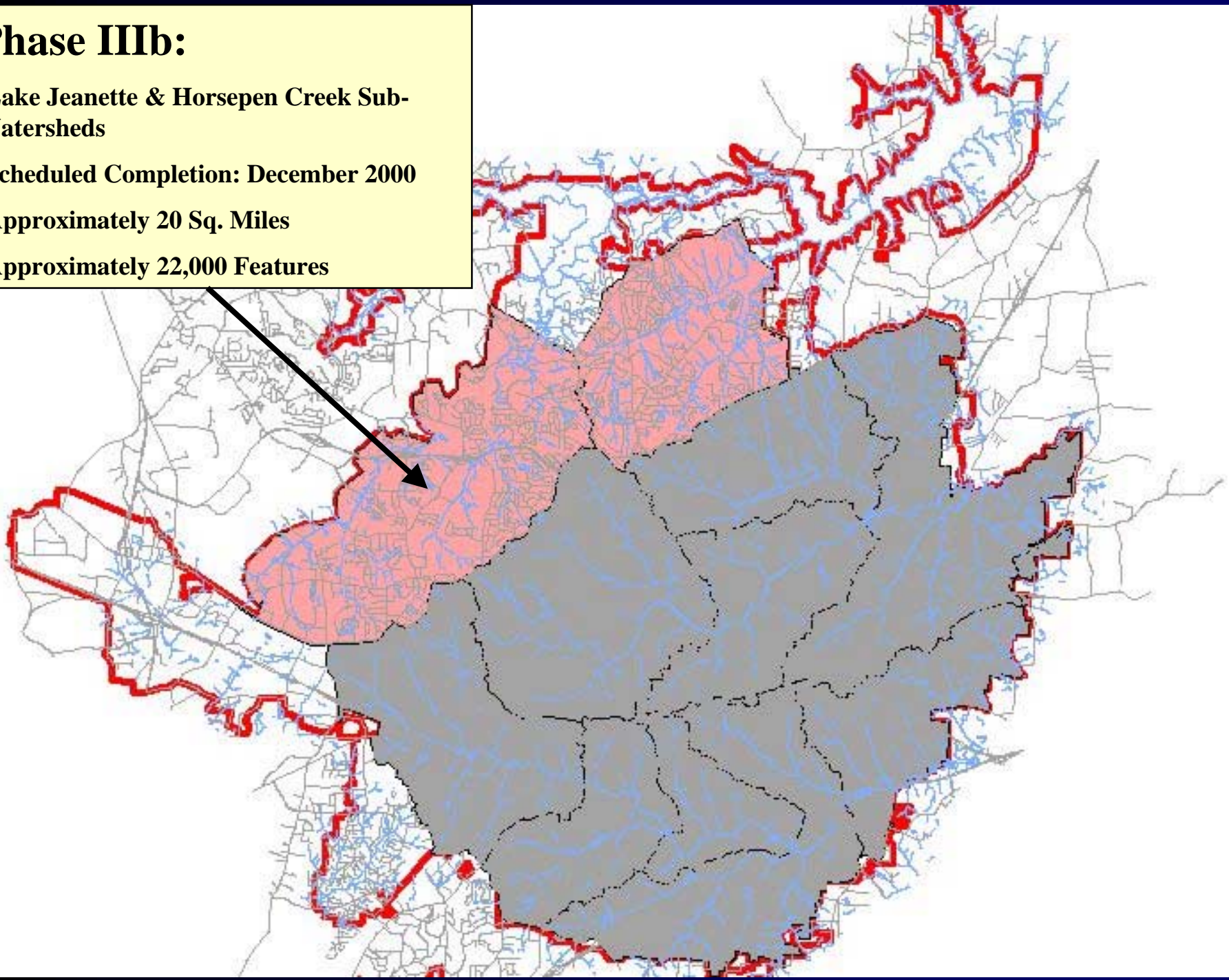
- North & South Buffalo Creeks 3&4
- Scheduled Completion: April 2000
- Approximately 29 Sq. Miles
- Approximately 32,000 Features
- ARC/INFO





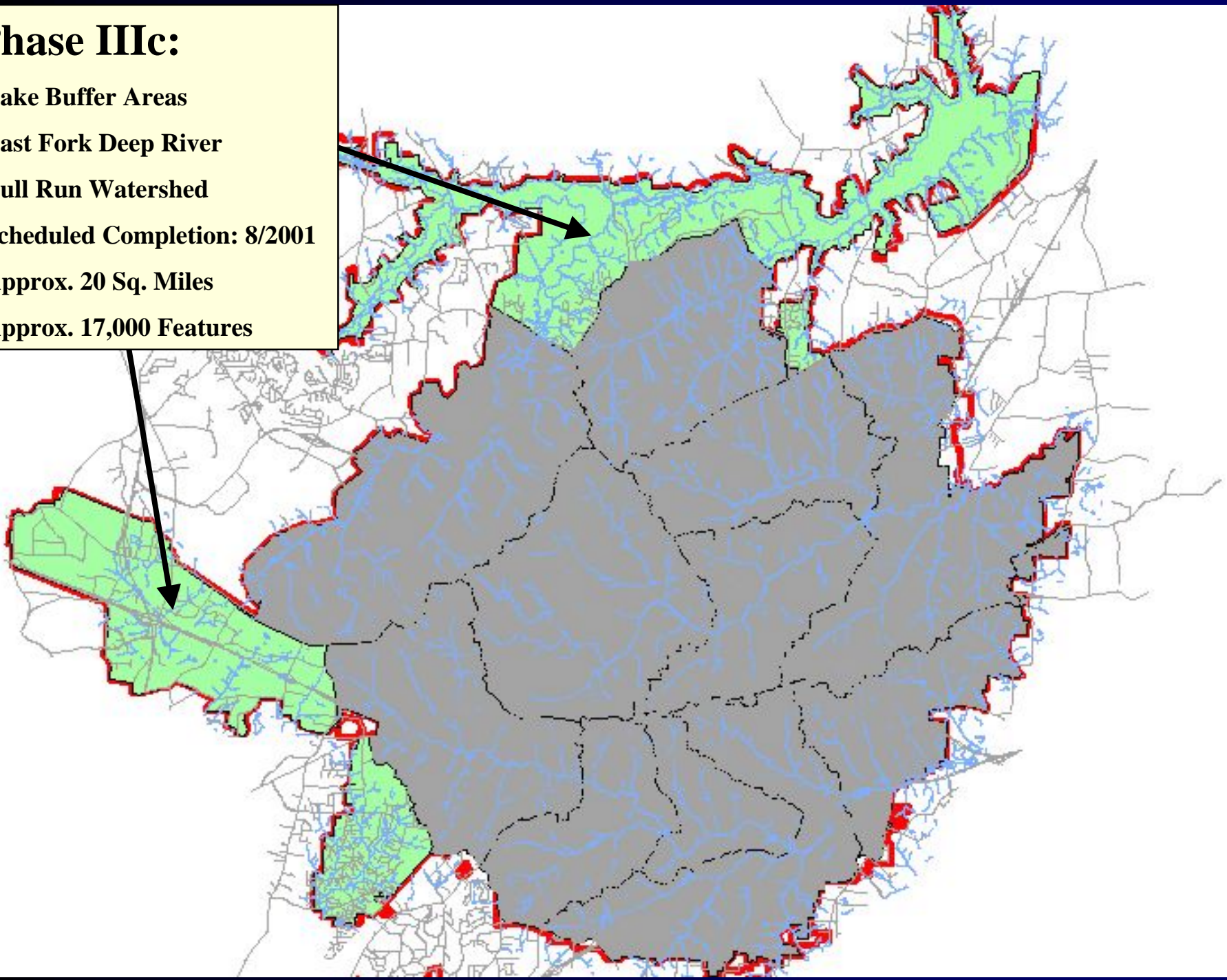
## Phase IIIb:

- Lake Jeanette & Horsepen Creek Sub-Watersheds
- Scheduled Completion: December 2000
- Approximately 20 Sq. Miles
- Approximately 22,000 Features



## Phase IIIc:

- Lake Buffer Areas
- East Fork Deep River
- Bull Run Watershed
- Scheduled Completion: 8/2001
- Approx. 20 Sq. Miles
- Approx. 17,000 Features





# By The Numbers...

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	<i>Project Phase</i>			
<i>Feature Type</i>	<i>Pilot</i>	<i>Phase II</i>	<i>Phase III</i>	<i>Totals</i>
Inlets / Manholes	2,366	16,838	14,584	<b>33,788</b>
Pipes	2,187	17,665	13,922	<b>33,774</b>
Culverts	64	219	248	<b>531</b>
Bridges	1	30	25	<b>56</b>
Lakes	5	36	32	<b>73</b>
Channels	177	1,100	1,350	<b>2,627</b>
Digital Pictures	-	3,200	16,366	<b>19,566</b>
Cross Sections Surveyed	-	275	331	<b>606</b>
<b><i>Totals</i></b>	<b>4,800</b>	<b>39,363</b>	<b>46,858</b>	<b>91,021</b>

**Data as of February 2, 2000**



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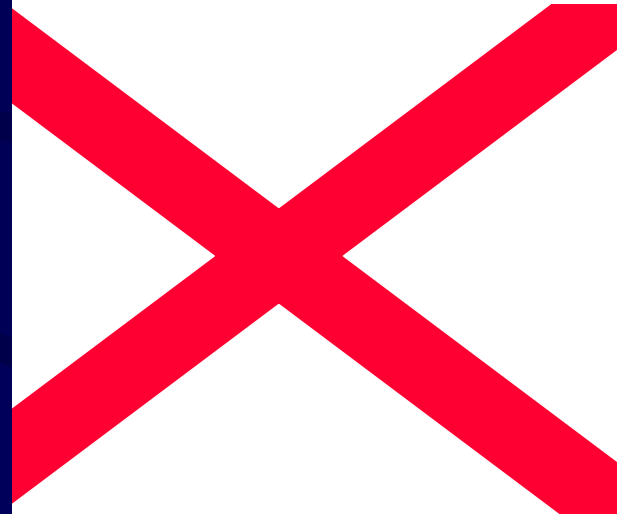
# Project Description

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- Developed GIS / Database Design
- Determined Scope / Accuracy Standards
  - Pipes larger than 12"
  - City / DOT and and Private Maintained Systems
  - Location Accuracy to +/- 5 cm
  - No Driveway Pipes
- Developed Quality Assurance Plan
- Established GPS Base Station Control Network
- Feature Attribution
- Feature Location - GPS and Traditional Survey Methods
- Quality Control
- GIS Data Integration
- Final Deliverable - ARC/INFO Coverage

# Feature Attribution

- Pen-based Field Computers
- Attributes Collected
  - Structure Size
  - Pipe Diameters
  - Material
  - Condition
  - System Connectivity (*Channels & Swales*)
  - Odors or Illicit Connections?
- Bridge / Culverts / Dams Attributed
- Digital Pictures



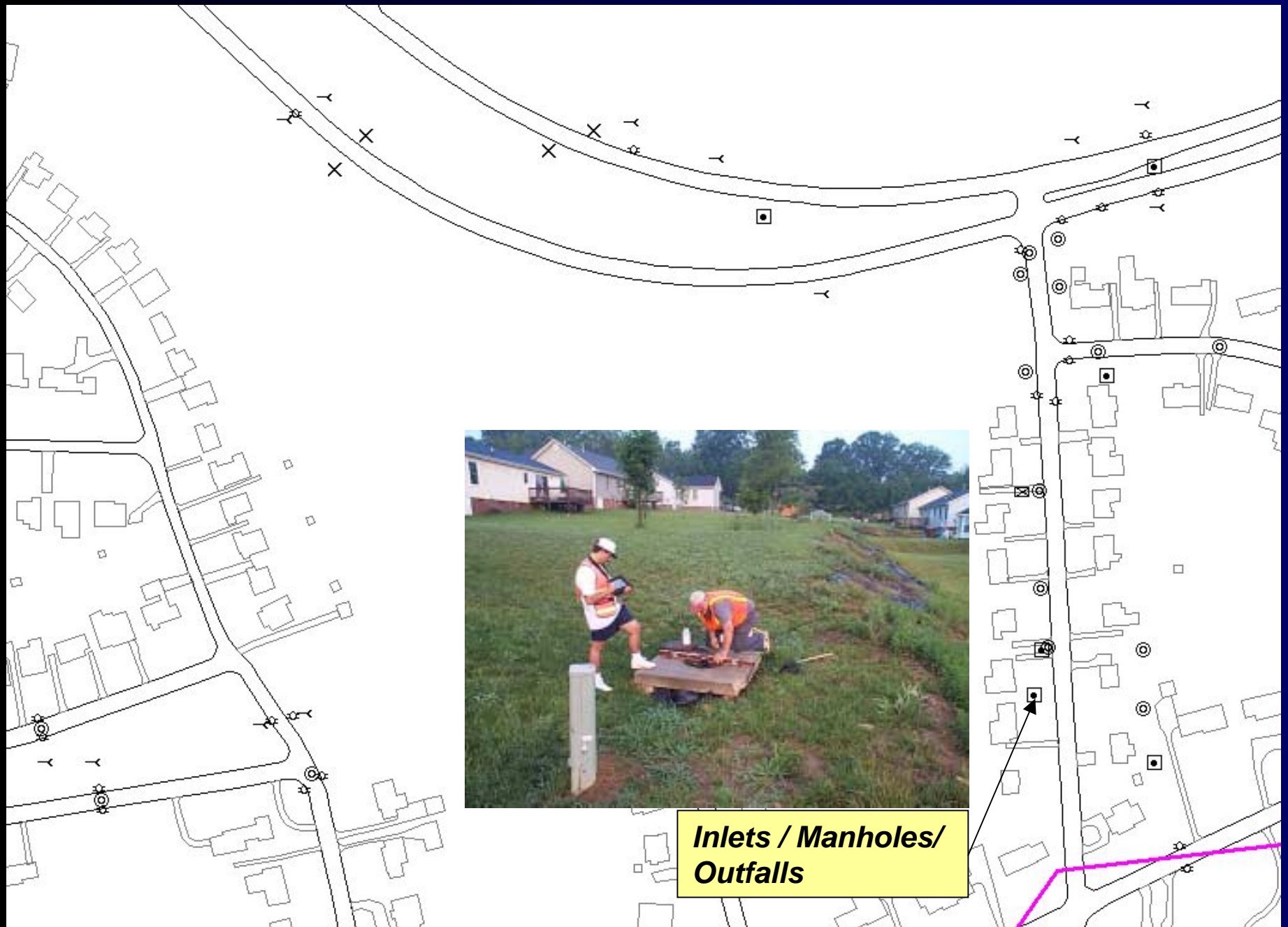
# GPS Location Surveys

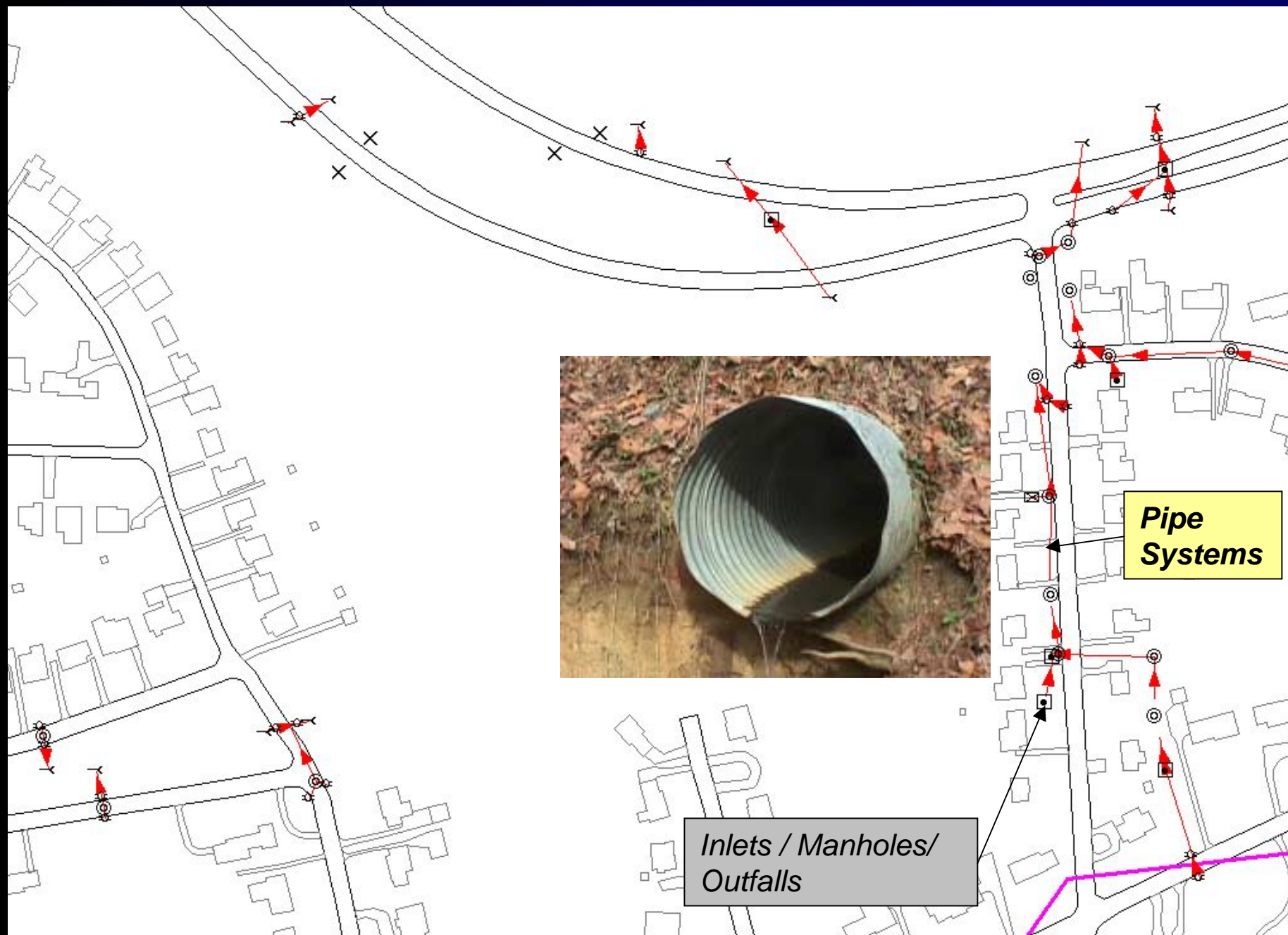
- GPS = Global Positioning Systems
- Accuracy: +/- 5 cm
- Approximately 50-70% of Points Are “GPS-able”
- 2 Person Field Crews Begin at Outfalls and Work Upstream
- Unique Identification Numbers
- Crews Trace System Connectivity
- Field Sketches of System





# What Is Complete System Connectivity ?



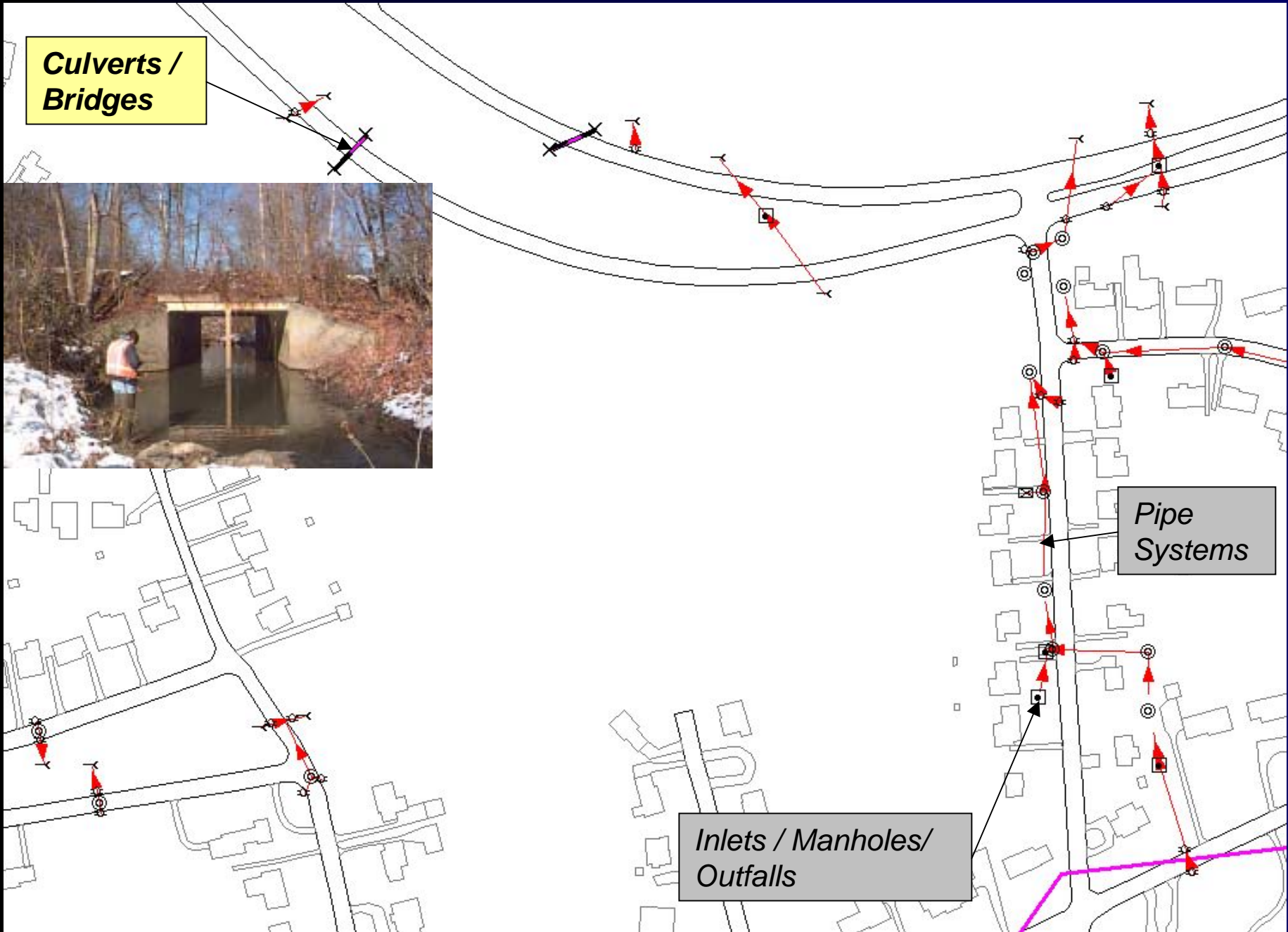


**Culverts /  
Bridges**



*Pipe  
Systems*

*Inlets / Manholes/  
Outfalls*





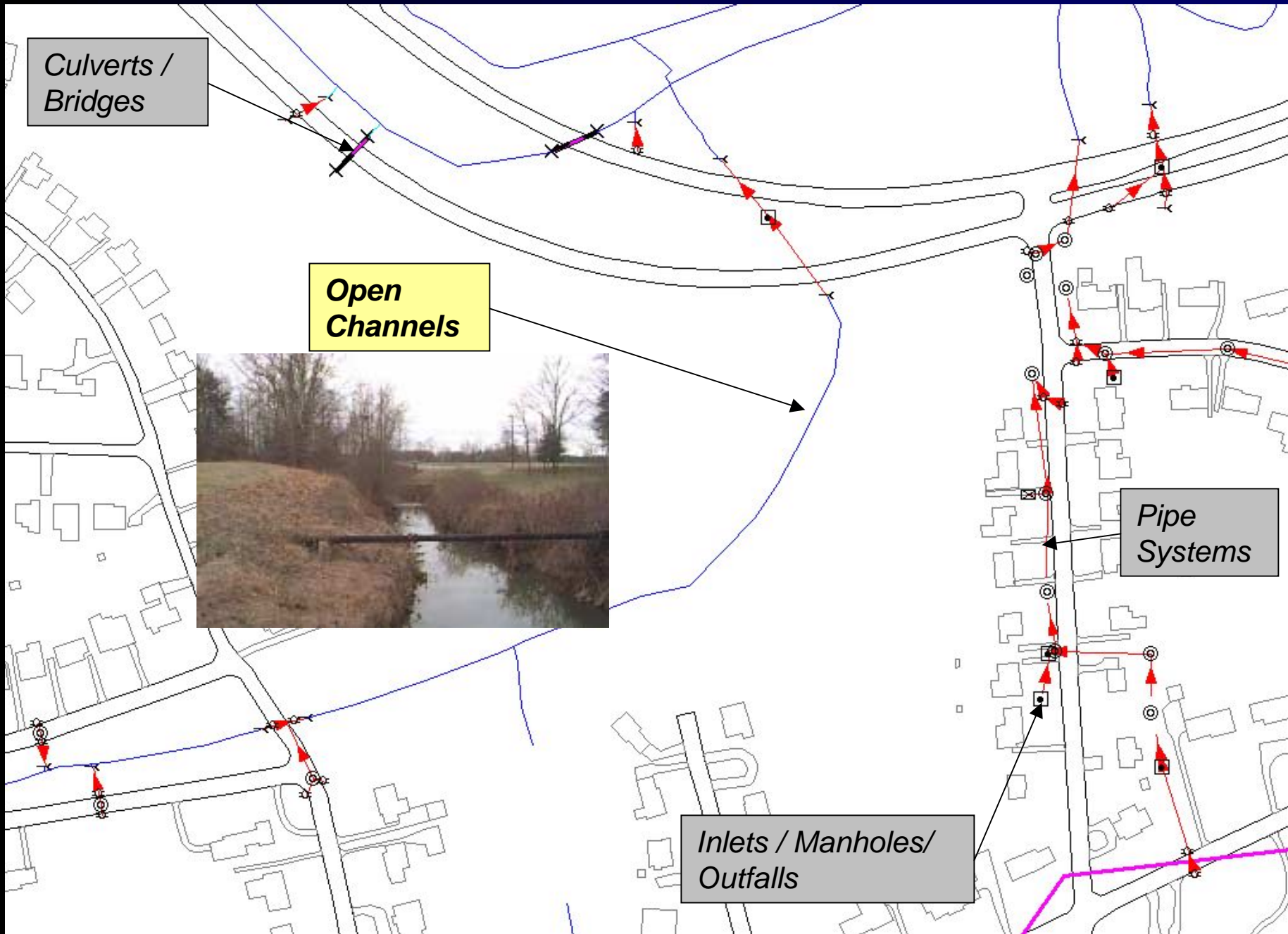
**Culverts /  
Bridges**

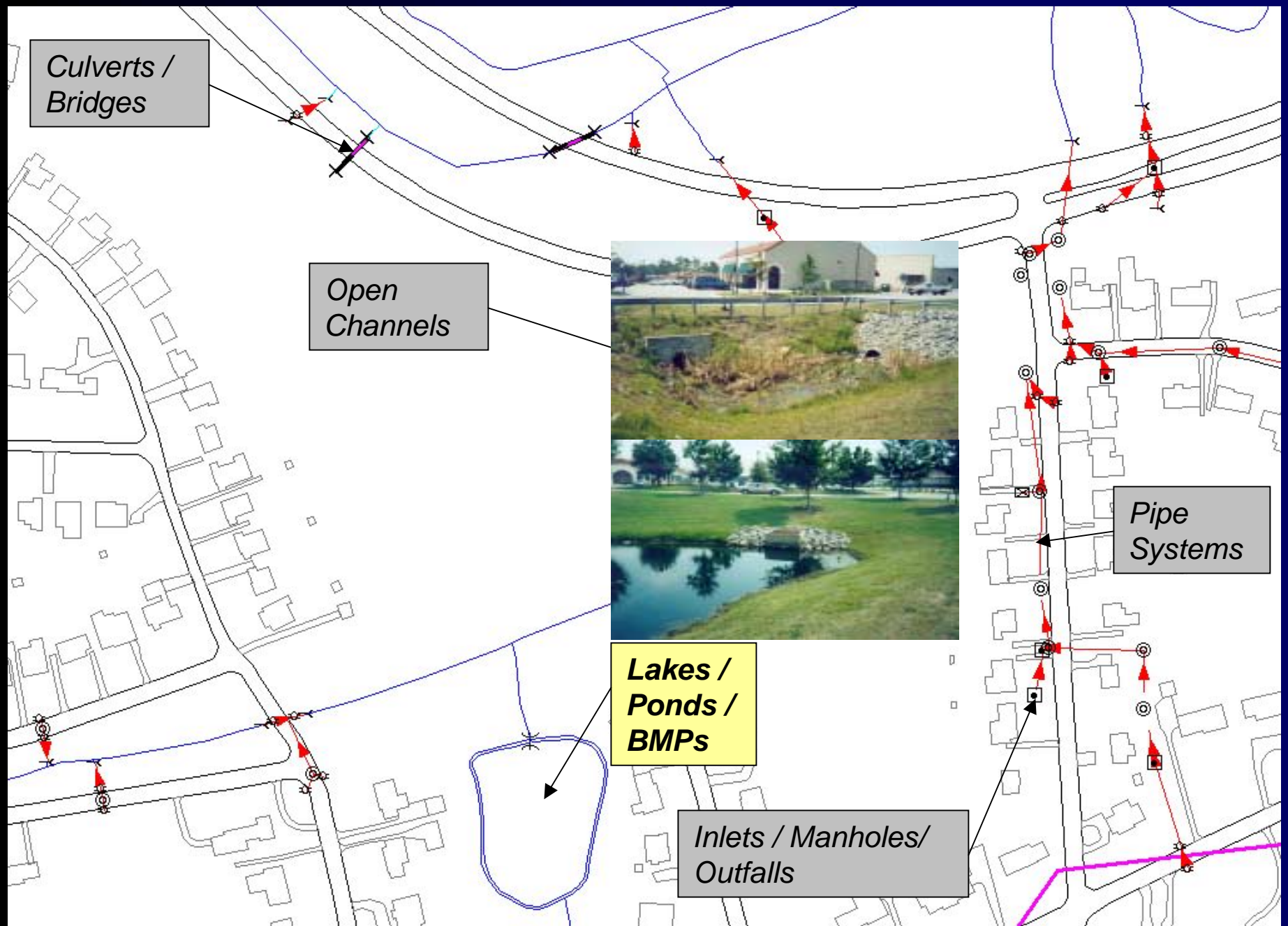
**Open  
Channels**

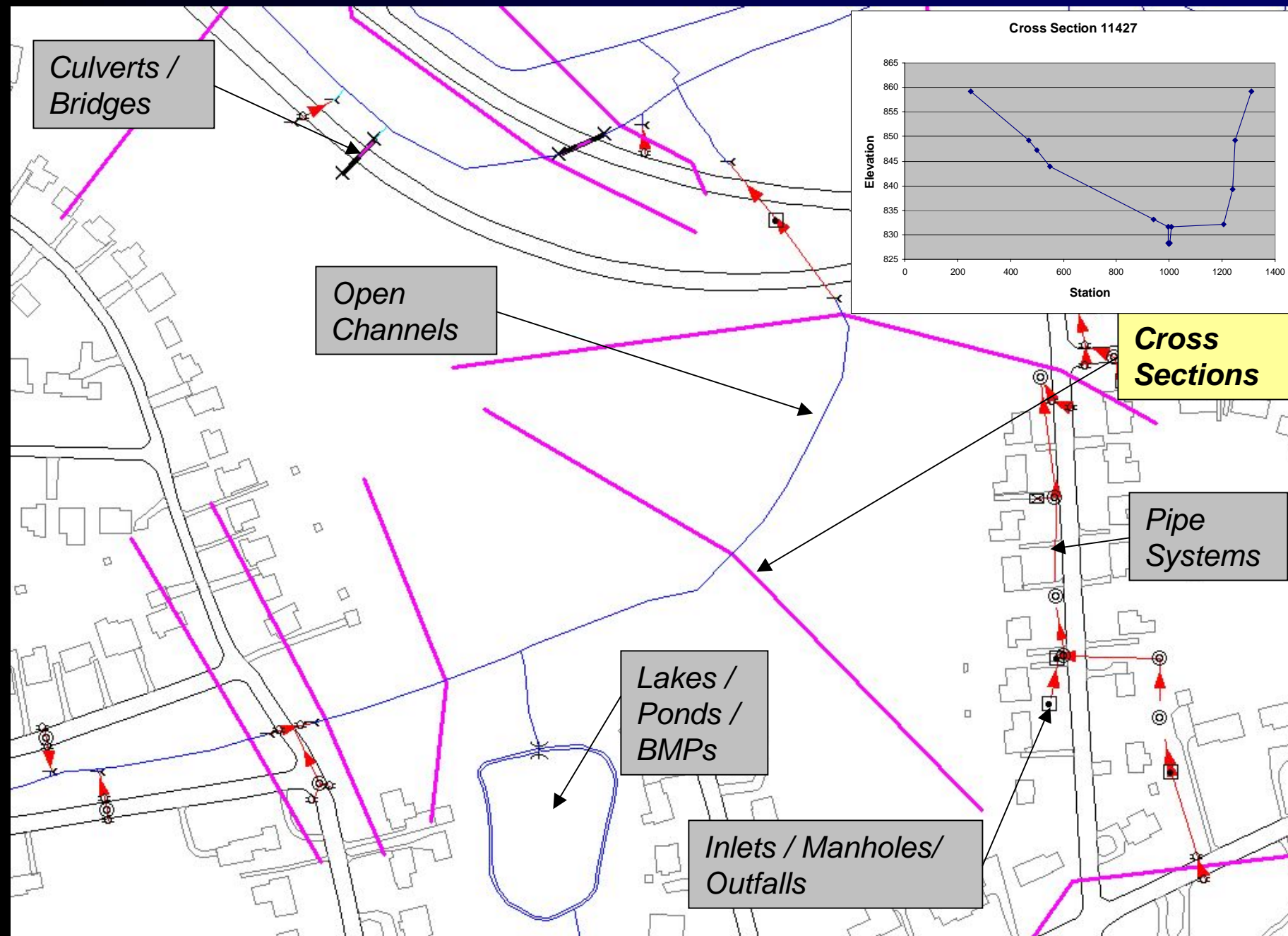


**Pipe  
Systems**

**Inlets / Manholes/  
Outfalls**









# Structure Condition Assessment

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# System Outfall Inventory

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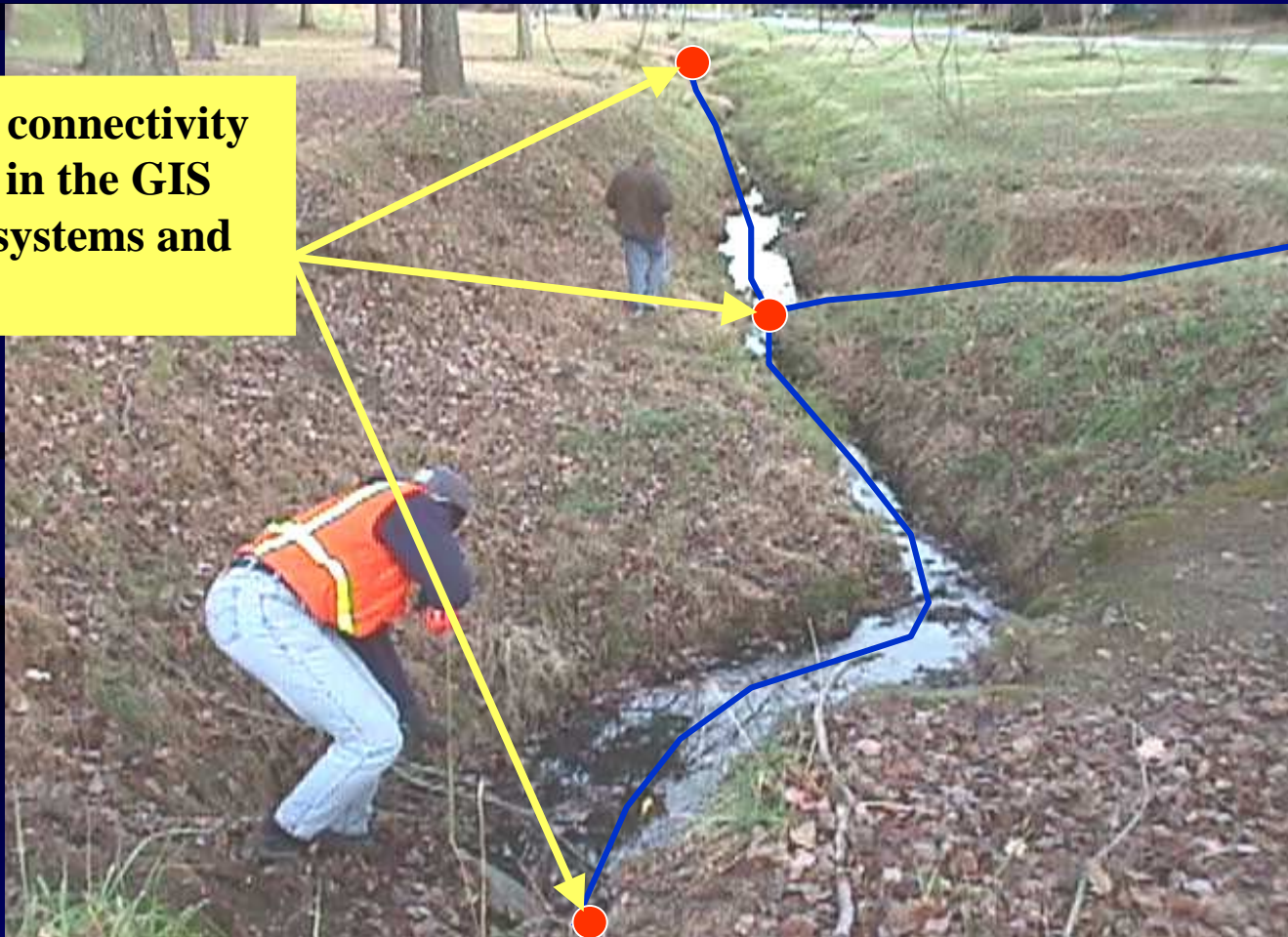


**Illicit Discharges Are  
Identified By Field  
Crews - City notified as  
soon as possible**

# Open Channel Inventory

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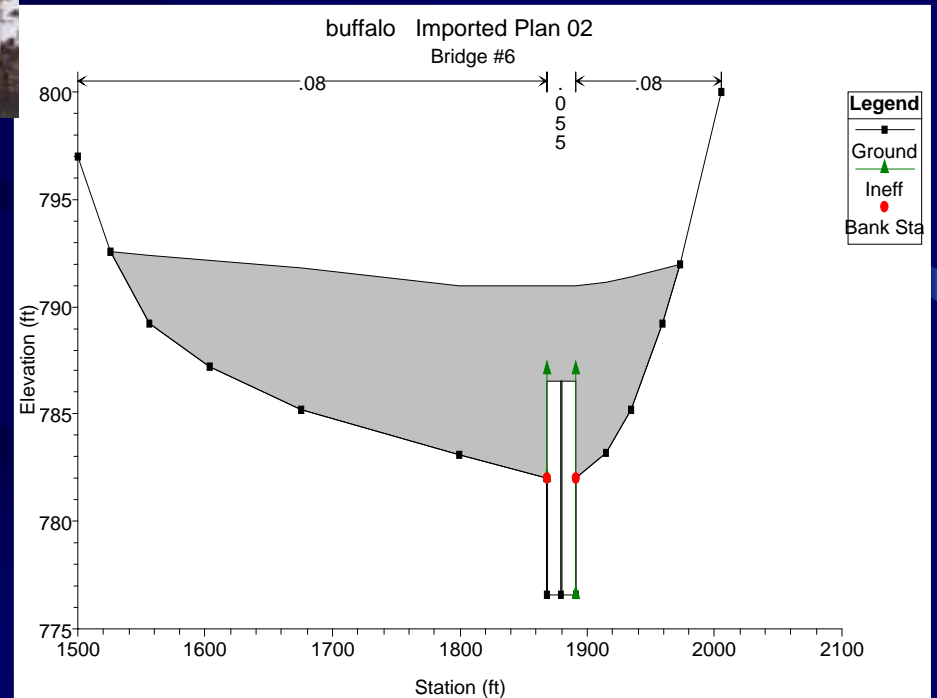
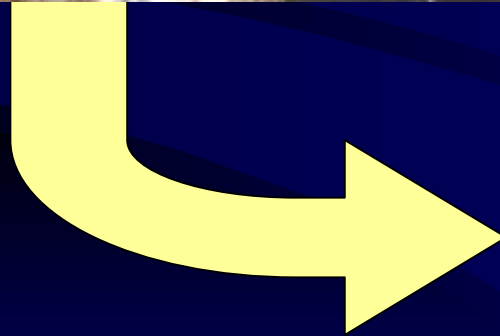
**Open channel connectivity is established in the GIS between pipe systems and culverts**



# Field → GIS → H&H Modeling



**Data is collected to easily import and link the GIS Inventory into standard hydraulic models (HEC-RAS)**





ArcView GIS Version 3.1

File Edit View Theme Analysis Surface Graphics XTools Window Dewberry WR 1.1 Help Edit Extension Lines From Table

Scale 1:1,879 1,762,590.61 863,046.41

View1

- ☒ Waterbody
- ☒ Pipe
- ☒ Culvert
- ☒ Stormwater Structures
  - CHANNEL
  - CINLET
  - GINLET
  - MANHOLE
  - PIPEIO
  - YINLET
  - SWALE
  - POINT
  - CBINLET
  - WATERB
- ☒ Channel
- ☒ Swale
- ☒ Bridge
- ☒ Base Map
  - BUILDINGS
  - DRIVEWAY
  - WORK AREA LIT
  - PAVEAREA

D:\gsoph3\photos\A00781.jpg

File Edit Image View Help

Attributes of Channel\_point\_theme.shp

Flow	Color	Odor	Chan_conf	Bank_heigh	Bottom_wid	Bottom_rad	Top_width	Lining_typ	Lining_con	Bed_type	Bank_condi	Su
moderate	Normal	no	rectangular	2.00	6.00	0.00	6.00	natural	good	rocky	stable	gra
light	Normal	no	trapezoidal	3.00	16.00	0.00	24.00	riprap	good	rocky	stable	gra
light	Normal	no	trapezoidal	3.00	5.00	0.00	20.00	riprap	good	rocky	stable	stc
light	Normal	no	rectangular	1.00	4.00	0.00	4.00	natural	good	clay/silt	stable	wc

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# Innovative Field Procedures

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- Pen Computers
- Custom Data Collection Software
- Custom Laser Measurement Device
- Quality Control
- Advanced Digital Camera Techniques
- Experienced and Properly Trained Field Crews

# Pen Computers

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- State-of-the-art pen computers
- Bring the GIS “...from the desktop to the street corner...”
- Eliminate Paper Field Notes
- Ruggedized / Waterproof for Extreme Conditions
- Interface with GPS Receivers



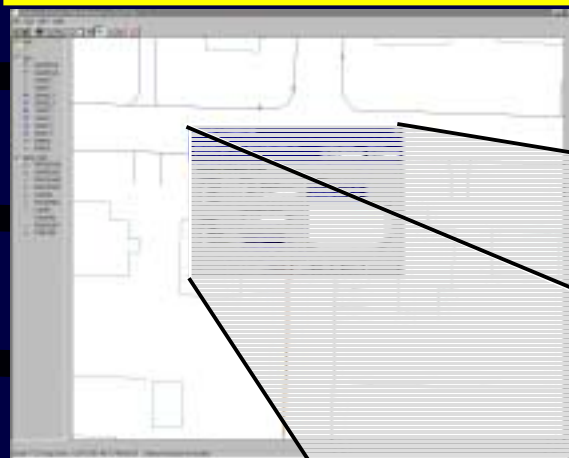
# Data Collection Software

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- Written in MapObjects / Visual Basic
- Data is Collected directly in GIS Format
- Custom Built for Stormwater Inventory
- “Wizard-Type” Dialog Boxes Guide Field Crews
- “On-the-fly” Quality Control Checks



# “Wizard” Type Dialog Boxes



Software **WILL NOT**  
allow the user to finish  
structure without 100%  
complete data.

**START ATTRIBUTION**

This form contains data fields which are general to ALL structures.

STRUCTURE **CINLET** GPS ID **10838**

**General Attribute Data**

Condition  
☒ Good  
☐ Fair  
☐ Poor

Photo  
☒ Yes Photo ID **D-051**  
☐ No

Surrounding surface  
**Asphalt**

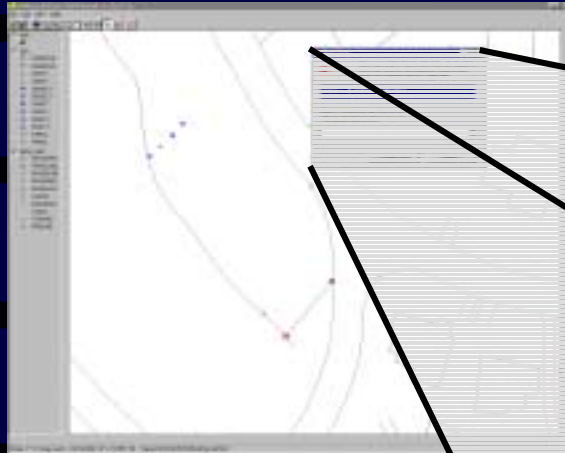
System  
☒ City  
☐ Private  
☐ Unknown

Standard for structure  
**402/403**


Comment  
**Optional comment for use by the CITY**

Cancel < Back Next > Finish

# “On-the-fly” Quality Control Checks



**Slope Error**

 Slope check failed. Go back and check your dropdowns, or you may continue after entering a comment below. (Note: this comment is for D&D usage only.)

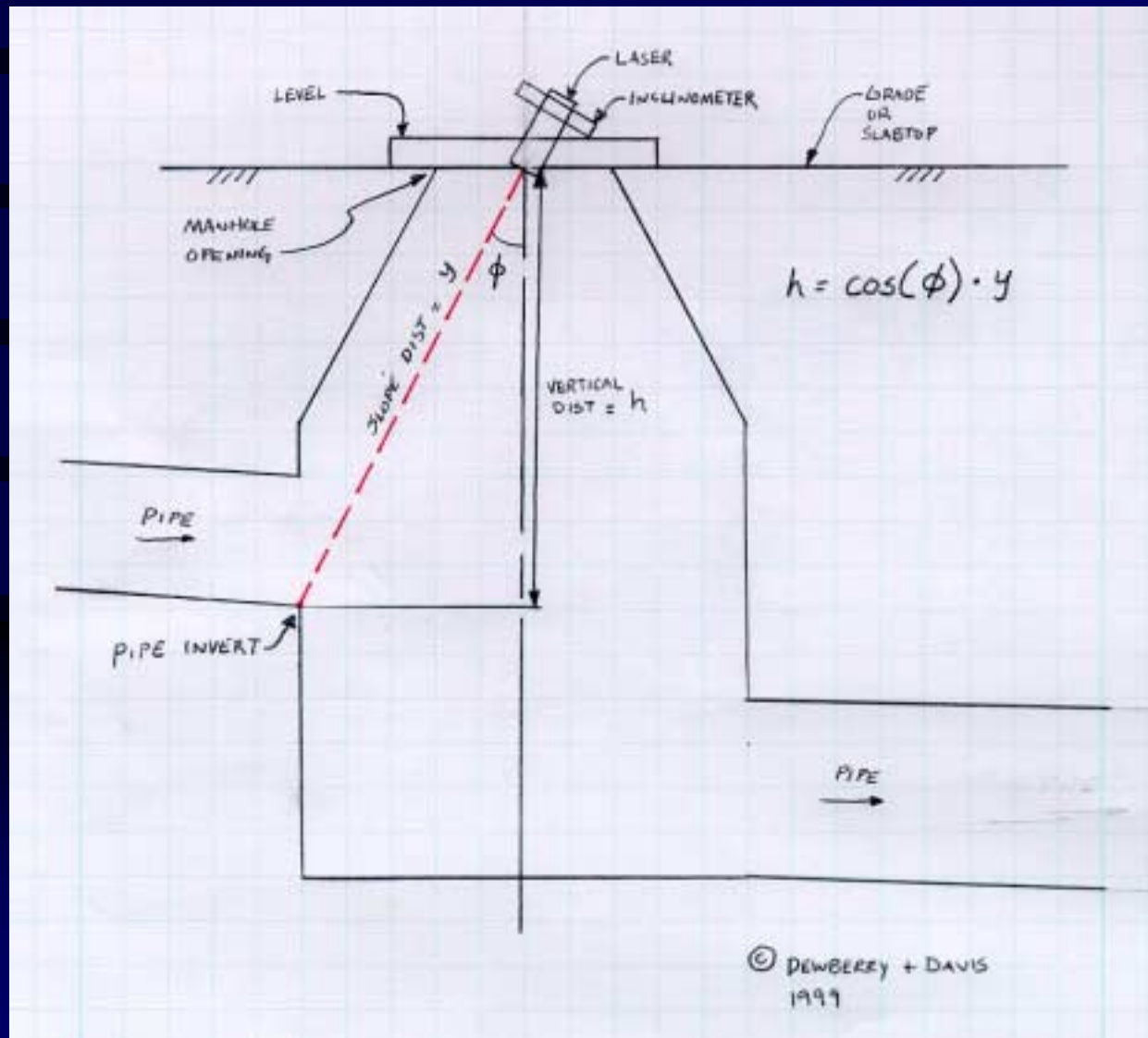
**slope = -0.18**

Select a comment from the pull-down list. You may also type your own.

<< Double check      Continue >>

**Users are warned of errors in the field - Revisits are virtually eliminated!**

# Custom Laser Device - *Plan*





# Custom Laser Device - *In Use*



**Pipe Inverts are measured to an accuracy of  $\pm 0.1'$**

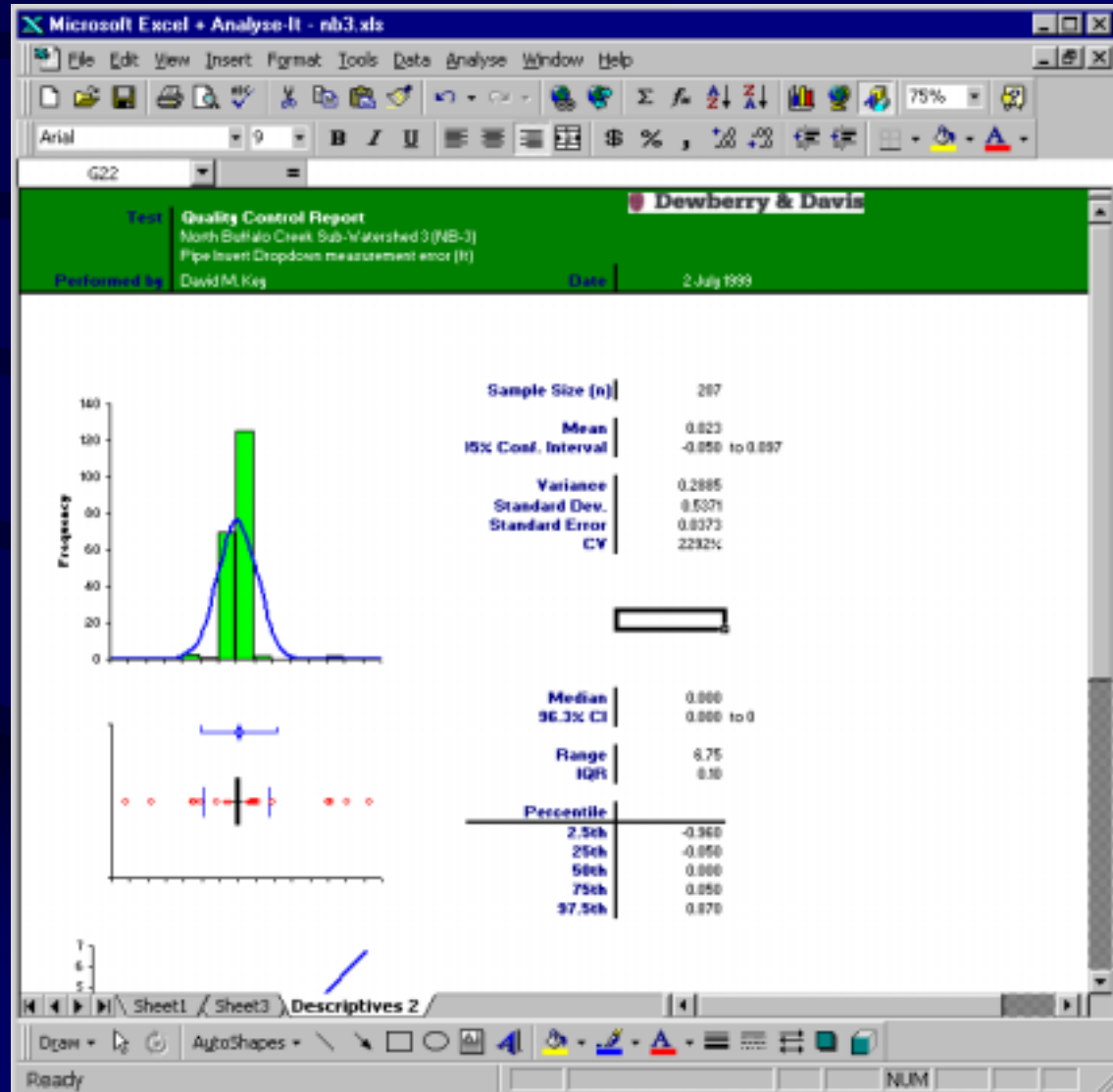
# Quality Control

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- “Independent” QC Crew Checks
- Check a Minimum of 5% of Features
  - Pipe Diameters
  - Pipe / Structure Inverts
  - Pipe / Structure Material
  - System Connectivity
  - Structure Conditions
- Statistical Analysis of Data
- Confidence Interval Testing

# Quality Control

- Statistical Analysis of Data
- Confidence Interval Testing





# The People Make the Project

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- City and Consultant work together in Partnership
- Crew Leaders are Engineers or GIS Specialists
- 100+ Page Field Inventory Procedures Manual
- 2 weeks Office/Field training

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# Problems / Pitfalls

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- RTK GPS vs. Trees and Buildings
- Suggest relative high accuracy for vertical data; less may be OK for horizontal
- Inaccessible Structures  
Know when to say when!
- Keep your inventory data current  
Don't make this only a "snapshot"
- Subjective Condition Ratings - training and consistency in the field is the key
- Process Data as you go!

# What Can You Do With The Data?



HEC-HMS

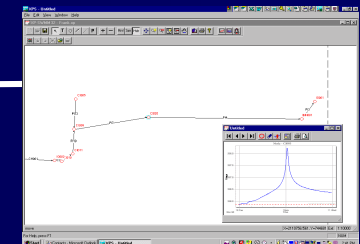
Water Quality



Stream Restoration



BMP Evaluation



XP-SWMM



HEC-RAS



Flood Plain Mapping



Work Orders